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A STUDY OF SOME POINTS

IN THE

PHYSIOLOGY OF DIGESTION.

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A STUDY OF SOME POINTS IN THE PHYSIOLOGY OF DIGESTION.

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THE FUNCTION OF THE CARDIAC AND PYLORIC PORTIONS OF THE STOMACH.

SOME time ago, in connection with my physiological lectures, I performed an experiment with the object of testing the function of the two divisions of the stomach. It would have no value alone, but it tends to confirm the observations of others, and may serve as a convenient text for the discussion of the subject of the present article.

And first a word in regard to the histology of the stomach as recently described.

The inner surface of the gastric mucous membrane is lined with cylindrical epithelium. The epithelial cells have two zones. The upper — that next the free surface — is the thicker, and is composed of protoplasm which is being changed into mucin (paraplasm of Kupfer[1]). The lower zone is protoplasm, and contains the nucleus. Many of the cells upon examination show the goblet shape which indicates the discharge of their mucoid contents. It is these surface cells which secrete most of the mucus that lines the stomach in the intervals between digestion.

The glands of the fundus are simple straight tubes, only occasionally branching at the base. Near the orifice they are lined with the cylindrical epithelium of the surface. In the remaining portion the gland is lined

[1] Kupfer. Berlin. klinische Wochenschr., xv., 47, p. 703, 1878.

with small columnar cells, the "chief cells" of histologists, and with large oval cells, the "border cells." The latter are placed between or external to the former.[1]

The glands of the pyloric end of the stomach are compound, as a rule, and are larger than those of the fundus. They are lined with an epithelium formerly confounded with that of the surface, but now believed to be essentially like the "chief cell" of the fundus.[2]

As regards the functions of these different glands and cells, the following views have the latest and strongest support: —

In the *fundus* there is secreted a juice which is very strong in acid (about .5 per cent.), and is also strong in pepsin. In the *pyloric* end there is secreted an *alkaline* viscid fluid which is strong in pepsin. The "chief cells," and the lining cells of the pyloric glands which resemble them, are especially concerned in secreting pepsin; the "border cells" are especially concerned in secreting the acid (H Cl) of the gastric juice.[3] The pepsin in the chief cells is thought to be partly in a perfected and soluble condition, partly in an insoluble form, analogous to that of zymogen in the pancreas.[4] The acid of the gastric juice transforms this insoluble "mother ferment" into the active and soluble pepsin.[5] The evidence for the above view is as follows: —

(1.) Partsch,[6] Swiecicki,[7] and others find that in the

1 Heidenhain and Rollett first and independently described these cells.

2 Kupfer. Vide loc. cit. Also Grützner. Archiv f. Physiolog., xx., 8 u 9, p. 395, 1879.

3 Edinger, Archiv f. mikr. Anat., vol. xvii., p. 193, thinks there is really but one kind of cell, and that the border-cells are developed from the chief cells. Herrendörfer supports this, as I think, untenable view.

4 Langley (J. N.), Journal of Physiol., vol. iii., Nos. 3 and 4, p. 269, 1882, thinks that pepsin is not found in the living stomach, but only pepsinogen. The granules of the gland cells are this pepsinogen.

5 Langley (Journal of Phys., January, 1882) thinks there is no free pepsin in the cells, but only the pepsinogen.

6 Partsch, C. Archiv f. mikros. Anat., xiv., 2, p. 179, 1877.

7 Swiecicki. Schmidt's Jahrbuch., clxxiv., p. 132.

œsophagus of the frog there is secreted an alkaline pepsin-building fluid, while in the stomach the secretion is acid. The œsophageal and gastric glands are distinctly separated. Now the gland cells of the frog's œsophagus resemble very closely the "chief cells" of mammals, while the gland cells of the frog's stomach are identified with the "border cells" described above.

(2.) Snippings from the gastric mucous membrane digest the more quickly the greater the number of "chief cells" they contain.[1]

(3.) Heidenhain,[2] who is the most prominent advocate of this view, has made a series of experiments which, he considers, settles definitely the question of the function of the pyloric glands. He isolated a portion of the fundus of the stomach in eight dogs and a portion of the pylorus in six dogs, of which latter three lived. By means of fistulæ he obtained the secretion from these different parts. That from the fundus was uniformly acid, containing, as an average of thirty-six tests, .52 per cent. of free H Cl, while the average in the ordinary gastric juice of the dog is about .3 per cent. It contained pepsin in good amount. The secretion from the pyloric fistulæ was constantly alkaline, very viscid, glassy in appearance, and rich in pepsin, though poorer than the fundus secretion. Upon the addition of acid fibrin is energetically digested.

This seems very conclusive. It should be stated, however, that Friedinger,[3] Von Wittich, Wolfhügel, and a few others have, until recently, at least, denied this peptic power of the pyloric secretion, one of their reasons being that infusions of the mucous membrane

[1] Ebstein and Grützner. Pflüger's Archivs, vol. vi., p. 1, 1872. Hermann's Elements of Physiology, p. 137, 1880.

[2] Heidenhain, R. Archiv f. Physiol., xix., 2 u. 3, p. 148, 1879. Also, Breslau Arztl. Ztschr., i., 4, p. 32, 1879; also in Archiv f. Physiol., xviii., p. 169, 1878, and in Hermann's Handbuch der Physiol., V. der Absonder pv., 1879.

[3] Friedinger. Wiener Sitzungsber., October 1871. See also Hermann's Elements of Physiol., loc. cit. Ebstein and Grützner and Klemensiewicz confirm Heidenhain.

are not active. According to my observations, the pyloric and cardiac portions of the stomach are more sharply distinguished in the dog than in man. So that we cannot draw inferences too confidently.[1]

(4.) My own investigations have simply a slight confirmatory value.

In the first place, in examining the stomachs of dogs killed during active digestion (and I have examined over fifty), I often noticed a large amount of thick, viscid, glassy-looking substance covering the pyloric end of the stomach. It was evidently secreted during active digestion, since I have not observed it in empty stomachs, and, therefore, was not mucus, but the same fluid obtained by Heidenhain from his pyloric fistulæ. It lined the pylorus, and extended through the sphincter. It seemed admirably adapted for lubricating the surface and helping along the passage of food. Such a function would not be superfluous in an animal like the dog, whose stomach so often contains ragged pieces of bone and foreign matters, and I cannot but think that the pyloric secretion has a lubricating as well as digestive function.

Experiment. A large dog, weighing about sixty pounds, was etherized, the stomach opened by an incision near the pylorus, and the organ thoroughly washed out. A ligature was thrown around the cardia (to prevent subsequent vomiting), and another ligature at about the junction of the cardiac and pyloric portions of the stomach. Previous to applying the latter ligature half an ounce of coagulated egg-albumen, cut up into half a dozen pieces, was inserted in the fundus. A like amount was inserted in the pyloric portion, and the incision carefully closed with a continued suture. The stomach of this dog was nearly as large as that of a man, and the capacity of the pyloric and cardiac cavities was about as two to three.

[1] In a very recent article (reviewed in the Berliner klinischer Wochenschr.) upon the secretion of the acid of the gastric juice, it is stated again that H Cl is secreted in the pyloric end of the stomach. The statement is not sufficiently supported as yet.

The dog recovered well, sat up, and moved around. He was given enough morphine to prevent his suffering pain. Six hours later he was killed, and the stomach opened. In the cardiac portion there had been absolutely no secretion of gastric juice. There was a little mucus on the surface. The reaction was neutral; the albumen was unchanged. In the pylorus there was considerable of the glairy secretion above referred to. The whole surface being carefully washed off, the fluid obtained was slightly acid. On testing it with alkali and copper in the usual way, a purple violet color, indicating peptone, appeared. The ligatures were found to be tight. That separating the cardiac from the pyloric portion was found to include a strip of the fundus from half an inch to an inch wide. A secretion from this part would explain the acid reaction. In large dogs the fundus and pyloric end are sharply marked off, the mucous membrane in the latter portion being thicker and without rugæ. The pieces of albumen were very slightly affected, the sharp edges being eaten off. The shock of the operation, which, owing to an accident, was unusually long, and the presence of the ligatures, had evidently almost entirely arrested secretion. But there was a moderate amount in the pylorus, and, as it seems to me, the fluid was of the same character as that obtained by Heidenhain.

In conclusion, we may consider it established that the fundus glands secrete an acid peptic juice and the pyloric glands an alkaline peptic juice. The latter probably has also some lubricating function. The special function of the "chief" and "border cells" in producing pepsin and acid respectively cannot be laid down so positively.[1]

VALUE OF PEPTONES AND OF PANCREATIC EXTRACTS.

I performed one series of experiments to test the

[1] It may be added that the secretion of Brüner's glands has been found to have peptic properties. As these glands are very similar in structure to those near the pylorus a similarity of function may also be inferred.

comparative absorbability of peptones and beef tea in the stomach.

Pepsin and trypsin under proper conditions turn albuminous bodies into peptone. The transformation is not, however, a direct one. The proteids are first turned into closely allied bodies which have received various names (parapeptone of Brücke, anti- and hemi-albuminose of Kuhne, propeptone, parapeptone, etc.). It is sufficient for my purpose to say that after the albumen is changed, and before it becomes peptone, it is on cooling precipitable with alcohol. We may speak, therefore, of "the precipitable products of digestion."[1] We shall refer to these again later on.

Peptone itself is now agreed to be a hydrate of albumen.[2] It can be turned back into an albuminous body by dehydrating agents and prolonged drying.[3] It is chiefly distinguished by its being, as compared with albuminous bodies generally, quite diffusible (Funke). Upon this fact, as has been supposed, depends its importance as a digestive product.

As to peptone being absorbable and nutritive there can be no doubt. Catillon[4] has shown that the administration of peptone alone may increase the weight and the excretion of urea, and this whether the substance be given by mouth or by rectum. Adamkiewicz,[5] Chapoteaut,[6] Defresne,[7] Raymond,[8] Bergeron,[9] Fowler,[10]

[1] Adamkiewicz. Virchow's Archiv, lxxv., 1, p. 144, 1879.

[2] Kossel, and Hoppe-Seyler. Schmidt's Jahrbuch., clxxii., p. 231.

[3] Heninger, A. Comptes Rendu, lxxxvi., 23, p. 1464, Juin 10, 1876.

Hofmeister, F. Prag med. Wochenschr., iii., 27, p. 271, Juli 3, 1878.

[4] Catillon, A. Bull. de Therap., xcviii., 3, p. 116, 4, p. 169, February 15, 29, 1880.

[5] Adamkiewicz, A. Die Natur u. der Nahrwerth des Peptones. Berlin, 1879. Berlin. klin. Wochenschr., No. 2, 1878.

[6] Chapoteaut, P. L'Union, 74, p. 947, Juin 12, 1880. Also Clinical Studies of the Peptones. Paris, 1881.

[7] Defresne, Th. Bull. de Ther., xcix , 1, p. 22, 1881, and Ibid., 5, p. 221, 1881.

[8] Raymond. L'Union, 24, p. 319, 1880.

[9] Bergeron, P. J. Gaz. des Hôp., 65, p. 515, 1880.

[10] Fowler, G. B. N. Y. Medical Journal, vol. xxix., p. 561.

have contributed evidence as to the value of peptones. Their relative value is even definitely given. Chapoteaut makes a "conserve de peptone," of which he estimates that one drachm is equal to five drachms of beef. Sanders[1] estimates that one part of flesh peptone is equal to three parts of beef, and one part of bread peptone to three parts of white bread.

So much in favor of the peptones.

On the other hand, some observers[2] have not found the good results described by those just mentioned, who by the way are, many of them, personally interested in the manufacture of the substances they recommend. Again, there is a practical objection to almost all, if not all, genuine peptones, in that their taste is disagreeable.

Finally, it is a question whether they are very much more *absorbable* and nutritive than ordinary beef-preparations or scraped lean and raw beef. For Adamkiewicz[3] has recently asserted that the diffusability of a proteid is no measure of its absorbability in the body; and that the "precipitable products of digestion," referred to above, are very easily absorbable, though not at all diffusable.

I made some experiments to test, if possible, the relative absorbability of peptones and beef extract so-called. Schmidt-Mulheim[4] has shown that peptones are rapidly absorbed or carried off in the stomach of dogs.

Experiment. Two dogs, therefore, weighing twenty pounds, were taken, and food kept from them for twenty-four hours. Gave No. 1 of beef-peptone (Gant's) two ounces; gave No. 2 of beef-essence two ounces. The preparations were both of about the same consistency.

[1] Sanders, H. (Amsterdam). Die Bedeutung der Verdauung für die Ernahrung, etc., S. L. E. a 8, 248 S.

[2] See Jour. de Therap., viii. p. 164, 1881.

[3] Vide loc. cit. Also J. Munk Physiol. des Menschen u. Sangethier, p. 169, 1881. Berlin.

[4] Schmidt-Mulheim, A., Archiv für Anat. u. Phys. (physiol. Abtheil), 1879, p. 39.

One hour and forty minutes later both were killed by drowning, and the stomachs examined. No distinct evidence of either beef-essence or peptone could be found in the stomach or intestine. The animals had swallowed some water, and the stomachs contained several ounces of a slightly yellowish fluid, which had no smell or taste of beef. So far as it went the experiment tended to show that the beef-essence was absorbed just as rapidly as the peptone in a healthy stomach. The facts of rectal absorption and of the absorbability of non-diffusible proteids lead to the view that peptones, if more valuable than beef preparations, are so only because they may contain more nitrogenous matter.[1]

A few experiments have been performed to test the value of pancreatic extracts. Although Roberts has called attention to the possible value of such a preparation, there has been until lately no good sample in the American market, so far as I can learn. And the pancreatic ferments have hardly been used at all medicinally in this country. Recently, however, a very active preparation containing the three (or four) ferments of the pancreas has been furnished by Messrs. Fairchild & Co., of this city. It will peptonize milk to a considerable extent or entirely within an hour. Another American preparation has been found by Mr. Moriarta to be active.[2]

[1] In estimating the value of the various beef and beef peptone preparations, it should be remembered that a healthy adult requires about four ounces of albuminous matter alone per day. There is nearly this amount in a pound of beef. The nutritive constituents of a pound of beef, therefore, cannot be gotten into much less than thirty teaspoons. The absurdity of the claims made for some beef preparations, for example, "one teaspoonful represents the nutritive properties of a pound of beef," etc., is therefore apparent.

[2] Mr. D. C. Moriarta suggests in New Remedies, May, 1882, the following as a standard test of the proteolytic power of pancreatic extracts: Mix five grains of the pancreatin with twenty grains of bicarbonate of soda and four ounces of water; add to this mixture one pint of milk previously warmed to 140° F., and set aside two hours in a warm place. If the milk is completely peptonized, so that acetic and nitric acids do not produce precipitates, the pancreatin may be considered of standard strength — in absence of official

The question is, however, whether trypsin or the pancreatic diastase will be of any avail when given by the mouth. It has been very conclusively shown (Ewald,[1] Langley,[2] Kuhne, Mays,[3] Mourrut, Defresne[4]) that the gastric juice under ordinary circumstances digests the pancreatic ferments. Langley brings forward strong evidence to show that each digestive ferment is destroyed in the section of the alimentary tract below where it is secreted. This destruction takes place also within from a few minutes (Langley) to one (Ewald) or in some cases two (Defresne) hours, depending on the amount of ferment and the acidity of the juice.

There is, however, this hope: Defresne and others assert that gastric juice, made acid with *organic* acids, has a much less feeble destructive power, and only *suspends* the activity of the pancreatic ferments.

Now this experimenter, as well as Richet, and, I believe, some other physiologists, contend that hydrochloric acid is secreted chiefly or entirely in the first part of digestion. If, therefore, the pancreatic ferments be given some time after a meal, "guarded," perhaps, as Roberts suggests, with bicarbonate of soda, their activity will not be destroyed.

But, on the other hand, there is very strong evidence that in reality the *organic* acids are secreted first, and that hydrochloric acid does not appear for nearly an hour after the ingestion of food.[5] At the best the

standard. If five grains is found insufficient, a larger quantity may be taken in a second experiment; or rather, to save time, several experiments may be made at the same time with five, ten, twenty-five, and fifty or one hundred grains of the pancreatin.

[1] Ewald, C. A. Vide op. cit. Appendix.

[2] Langley, J. N. J. N. Journ. of Phys., January, 1882.

[3] Mays, K. Untersuch. a. d. physiolog. Inst. d Universt. Heidel., 3, 378.

[4] Defresne, Th. Etudes Experimental. sur la Digestion. Paris, 1880. Baillière et Fils.

[5] See in support of this view: Von den Velden, R. (Strasbourg), Ztschrt. f. Physiol. Chem., iii., 3, p. 205. Also Deutsches Archiv f. klin. Medic., xxv., 1, p. 105, 1879. Uffelmann, J. Deutsches Archiv f. klin. Medicin., xxvi., 5 u. 6, p. 431, 1880. Fleischer, R. (Erlangen), Jahresbericht. d. Gesellsch. f. Natur. u. Heilkun. in Dresden, p. 77, 1881.

pancreas ferments must be given with uncertainty, therefore.

Besides, it should be remembered that the stomach is the great organ for digesting proteids, and the attempt to throw any great load upon the pancreas is but a makeshift. According to Bechamp's[1] experiments trypsin is less powerful than pepsin, and others have confirmed his opinion. When very large amounts of vegetable diastase are given, as in the malt extracts, it is possible that some passes into the intestine undestroyed.

In conclusion, I would say that peptones are valuable, but more because they contain much nutriment than because they are very absorbable. They increase metabolism.

Pancreatic extracts have not been proved to be of value when given medicinally, and they are probably destroyed in the stomach. They may be of much use, however, in partially peptonizing foods before such foods are used.

[1] Bechamp, A. Comptes Rendus, xcii., 3, p. 142, 1881.